



THE FRANKLIN
INSTITUTE *Awards*
& CONVOCAATION

APRIL 19-MAY 5, 2022



The 2022 Franklin Institute

AWARDS CONVOCATION

APRIL 19-MAY 5, 2022

Welcome to The Franklin Institute Awards, the oldest comprehensive science and technology awards program in the United States. Since 1824, the Institute has recognized more than 2,000 extraordinary individuals who have shaped our world through their groundbreaking achievements in science, engineering, and business. At a time when the importance of scientific advancement and technological achievement resonates more than ever, The Franklin Institute Awards Program continues its nearly 200-year legacy of honoring the most impactful discoveries and developments and those who have made them.

From explaining tiny ocean organisms to leading a mission beyond our solar system, from uncovering the mechanisms behind psychiatric disorders to helping us understand human nature, and from solving biological mysteries to lighting the world, this year's Franklin Institute Awards laureates each reflect Benjamin Franklin's trailblazing spirit.

Perhaps most timely, we are honored to recognize five central figures in the development, manufacture, and distribution of COVID-19 vaccines. In large part due to their efforts, we are delighted to return *in-person* to celebrate our Class of 2022 at The Franklin Institute Awards Ceremony and Dinner.

In addition, the Institute is pleased to present a series of in-person, hybrid, and virtual events highlighting our laureates and their extraordinary achievements. In this convocation book, you will find their

biographies and a schedule of events. We invite you to read about the laureates and attend the events to learn more.

The COVID-19 pandemic has made clear how crucial science and engineering are to public health, economic stability, and our understanding of the world around us. We are grateful for the scientists and engineers, public health officials and industry leaders, healthcare workers and vaccine and drug trial participants, and all of you whose careful diligence helped keep our communities safe. We look forward to seeing you, in person or online, this spring.



A handwritten signature in white ink, reading "D. Morel, Jr.".

Donald E. Morel, Jr., Ph.D.
CHAIR, BOARD OF TRUSTEES
THE FRANKLIN INSTITUTE



A handwritten signature in white ink, reading "Larry Dubinski".

Larry Dubinski
PRESIDENT AND CEO
THE FRANKLIN INSTITUTE

CONTENTS

- 2 History
- 4 Schedule
- 5-22 Laureates
- 23-26 Committees, Trustees, and Supporters

FOR MORE INFORMATION, CONTACT:

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bscheraga@fi.edu
www.fi.edu/awards

THE FRANKLIN INSTITUTE AWARDS

The venerable history of The Franklin Institute Awards dates back to 1824, when the Institute was founded by a group of leading Philadelphians to train artisans and mechanics. Philadelphia, then the largest city in the United States, was the nation's innovation and manufacturing center. The same year, the Institute arranged the first of what became a series of regular exhibitions of manufactured goods. With the exhibitions came the presentation of awards—first certificates and later endowed medals—for technical achievement.

Since 1875, recipients have been selected by the Institute's Committee on Science and the Arts (CS&A), formerly known as the Committee on Inventions. This all-volunteer committee of distinguished scientists and engineers from industry and academia still selects recipients of the Benjamin Franklin Medals and NextGen Award, dedicated to their charge to recognize the most impactful advances in science and engineering.

Celebrating outstanding achievements in science and technology from around the world is an important way The Franklin Institute preserves Benjamin Franklin's legacy.

In 1998, the Institute's long-standing endowed Awards Program was reorganized under the umbrella of the Benjamin Franklin Medals, now presented in seven areas of science and engineering. The Bower Award for Business Leadership and the Bower Award and Prize for Achievement in Science are made possible by a bequest in 1988 from Philadelphia chemical manufacturer and philanthropist Henry Bower, the grandson of a 19th century Franklin Institute laureate. The Bower Science Award is presented in a different, predetermined field each year and includes a cash prize of \$250,000. Benjamin Franklin Medalists and Bower Awardees each receive a 14-karat gold medal.

2021 marked the launch of the Benjamin Franklin NextGen Award, the first new award to be established in more than 30 years, and the only award to specifically recognize young researchers whose work is proving transformational in their fields.

Through its Awards Program, The Franklin Institute seeks to provide public recognition and encouragement of

excellence in science and technology. The list of Franklin Institute laureates virtually charts their advancement through the past two centuries—from the development of the typewriter to the dawn of quantum computing. The honor roll of more than 2,000 Franklin Institute Awards laureates includes Nikola Tesla, Marie and Pierre Curie, Rudolf Diesel, Orville Wright, Thomas Edison, Max Planck, Albert Einstein, Frank Lloyd Wright, Stephen Hawking, Gordon Moore, Jane Goodall, Elizabeth Blackburn, Steven Squyres, Dean Kamen, Subra Suresh, Cornelia Bargmann, Jim Allison, and Frances Arnold—to name but a few.

The Franklin Institute

In the spirit of inquiry and discovery embodied by Benjamin Franklin, the mission of The Franklin Institute is to inspire a passion for learning about science and technology.

As the most visited museum in the Commonwealth of Pennsylvania, The Franklin Institute is one of the country's leading science centers. Science and technology have the potential to solve some of the most critical issues of our time, to improve our lives, and to inspire our curiosity about the world around us. Every day, The Franklin Institute provides resources that help people connect with science and technology in creative ways that resonate with learners of all ages and backgrounds. The Institute directly reaches more than one million people each year with informal learning experiences that engage students, adults, and families. Reaching beyond the central learning space of its historic museum, the Institute has evolved to provide people with educational resources in their own neighborhoods through hands-on activities in classrooms, workshops in libraries, community centers, and other settings, and online engagement. The Franklin Institute is committed to making these resources available to as many people as possible throughout the Mid-Atlantic region and beyond.

THE FRANKLIN INSTITUTE LAUREATES

The Franklin Institute congratulates the 2022 Franklin Institute laureates, trailblazers in their fields who have benefitted humanity and deepened our understanding of the universe and its inhabitants.



Paul Slovic, Ph.D.

Bower Award and Prize for
Achievement in Science



Sallie W. Chisholm, Ph.D.

Benjamin Franklin Medal in
Earth and Environmental Science



*Stéphane Bancel,
Albert Bourla, DVM, Ph.D.,
and Alex Gorsky*

2022 Bower Award for Business Leadership



*P. Daniel Dapkus, Ph.D. and
Russell D. Dupuis, Ph.D.*

Benjamin Franklin Medal in
Electrical Engineering



Kafui Dzirasa, M.D., Ph.D.

Benjamin Franklin NextGen Award



*Katalin Karikó, Ph.D. and
Drew Weissman, M.D., Ph.D.*

Benjamin Franklin Medal in Life Science



Sheldon Weinbaum, Ph.D.

Benjamin Franklin Medal in
Biomedical Engineering



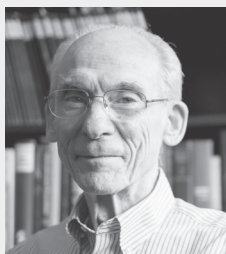
Edward C. Stone, Ph.D.

Benjamin Franklin Medal in Physics



*Carol V. Robinson DBE, FRS,
FRSC, FMedSci*

Benjamin Franklin Medal in Chemistry



Awards Event Schedule

This year's slate of laureate programs includes in-person, hybrid, and virtual events. All times listed are Eastern Time (ET). For additional information on each program, including featured speakers, location details, and participation instructions, please visit www.fi.edu/awards-schedule.

TUESDAY, APRIL 19, 2022

7:00–8:00 PM **VIRTUAL EVENT**

Inspiring Minds

Discussion with Kafui Dzirasa,
2022 Benjamin Franklin NextGen Award

Hosted by The Franklin Institute

MONDAY, MAY 2, 2022

9:30 AM–4:30 PM **HYBRID EVENT**

Exploring Intact Protein Assemblies with Mass Spectrometry

Laureate symposium featuring Dame Carol Robinson,
2022 Benjamin Franklin Medal in Chemistry

Hosted by the University of Delaware

7:00–8:00 PM **VIRTUAL EVENT**

Against the Odds

Discussion with Katalin Karikó and Drew Weissman,
2022 Benjamin Franklin Medal in Life Science

Hosted by The Franklin Institute

WEDNESDAY, MAY 4, 2022

8:30 AM–12:00 PM **HYBRID EVENT**

From Solving Mysteries in Cellular Biomechanics, to Vulnerable Plaque Rupture, to Jet Trains that Ski

Symposium honoring Sheldon Weinbaum,
2022 Benjamin Franklin Medal in Biomedical Engineering

Hosted by Villanova University

Additional partner: Temple University

9:00 AM–1:00 PM **HYBRID EVENT**

Layer by Atomic Layer: MOCVD Growth for a Carbon Neutral Society

Symposium honoring P. Daniel Dapkus and Russell Dupuis,
2022 Benjamin Franklin Medal in Electrical Engineering

Hosted by Drexel University

11:00 AM–12:30 PM **HYBRID EVENT**

The Future of mRNA Therapeutics

Laureate address by Katalin Karikó and Drew Weissman,
2022 Benjamin Franklin Medal in Life Science

Hosted by Drexel University College of Medicine

THURSDAY, MAY 5, 2022

9:00 AM–12:30 PM **HYBRID EVENT**

Social Innovation: From Bench to Society

Laureate symposium honoring Kafui Dzirasa,
2022 Benjamin Franklin NextGen Award

Hosted by the Department of Genetics, University of Pennsylvania Perelman School of Medicine

Additional partners: Mahoney Institute for Neuroscience and Department of Bioengineering, University of Pennsylvania

THE FRANKLIN
INSTITUTE *Awards*
CEREMONY & DINNER

THURSDAY, MAY 5, 2022
5:30 PM

Presented by **BANK OF AMERICA** 

For event information, visit
www.fi.edu/awards/ceremony-and-dinner

Michael Innocenzo
2022 Awards Corporate Committee Chair

Gregory E. Deavens
2022 Awards Corporate Committee Vice Chair

Melissa M. Trala
2022 Friends Committee Chair

Heather S. Bittenbender
2022 Friends Committee Vice Chair

BOWER AWARD AND PRIZE FOR ACHIEVEMENT IN SCIENCE THEME: DECISION MAKING



Paul Slovic, Ph.D.

President
Decision Science Research Institute
Eugene, Oregon

Professor of Psychology
University of Oregon
Eugene, Oregon

CITATION: For foundational theoretical and empirical contributions to the study of decision making, including understanding perceptions of individual and societal risk, and cognitive and emotional factors affecting preference. His research shapes policy in fields ranging from health and medicine to government and industry.

As we watch the news, particularly during the past two years amid the global COVID-19 pandemic, we are constantly being inundated with numbers and figures: numbers of cases, casualties, deaths. At first, the numbers may be shocking, but as they become endlessly repeated and revised, we find ourselves beginning to tune out. The staggering differences between the deaths of ten, one hundred, one thousand, or even one million people seem to have little effect.

Why do we become inured to mass suffering and death, despite being caring and humane people who wish only the

best for others? This is the result of a phenomenon called "psychic numbing," arising from the limitations of our own psychology and how we process information, and it is a concern because it can lead to apathy, cynicism, and an unwillingness to help the victims of disaster and misfortune. Paul Slovic has spent his career studying this and other perplexing aspects of how humans think, perceive, make judgments and decisions, and act individually and interpersonally.

Born in Chicago and raised throughout the Midwest, Slovic was interested in numbers, percentages, and statistics from a young age, not out of scientific but rather athletic enthusiasm. He was awarded a basketball scholarship to DePaul University, but instead of the NBA, the course of his life soon drew him to psychology and Stanford University, where he learned how to adapt his mathematical talents to psychological research. After earning his doctorate at the University of Michigan in 1964, he devoted himself to the study of risk and decision making, working with his close colleague Sarah Lichtenstein at the Oregon Research Institute. Later, with Lichtenstein and Baruch Fischhoff, he founded the Decision Science Research Institute, an independent research center known as "Decision Research." In 1986, he also became a professor of psychology at the University of Oregon.

Slovic, Lichtenstein and Fischhoff studied gamblers, stock market investors, and others making voluntary or involuntary choices: how they weigh risks and payoffs, how factors such as background and social status affect choice, and how various ways of describing outcomes and courses of action affect choices and risk assessments. Is risk-based choice a matter of reasoning, intuition, or some dynamic interplay of both? Do people behave differently depending on whether they are facing common or extreme situations? Slovic pushed the answers to these and other questions in new directions by applying data-driven psychometric research methods, often considered more the province of economics than psychology. His unique insights helped to weld the two fields together into the new discipline of behavioral economics.

Slovic's work demonstrates that the study of risk has ramifications far beyond the individual and personal level, bearing directly on matters of public policy and social issues. The COVID-19 pandemic is only the most recent illustration of how differing perceptions of risk can profoundly affect choices not only on the individual but also on the national

and global scale. Slovic has shown that perceptions of risk have affected policy decisions on issues such as nuclear power, genocide, nuclear war, domestic violence, climate action, and the response to natural disasters.

Is risk-based choice a matter of reasoning, intuition, or some dynamic interplay of both?

Research by Slovic and his colleagues has developed several highly influential theories, among them the "affect heuristic," which is the tendency of people to sometimes make quick decisions based on intuitive feelings and emotion rather than slow and careful reasoning. Slovic's "psychometric paradigm" provides a means of measuring the perception of risk and benefit and how various contextual and emotional factors affect it.

Slovic is also widely known for his study of psychic numbing, an idea first codified by psychiatrist Robert Jay Lifton. Psychic numbing is a response to tragedies on a massive scale, such as in the Holocaust, nuclear war, or, as we are now seeing, deadly global pandemics. Slovic finds that despite the better angels of our nature, the sheer number of victims involved in such disasters leads us to a sense of helplessness and inattention. He shows that changes in how mass tragedies are reported and presented can minimize apathy and motivate action to help the afflicted and to prevent future catastrophes. The importance of Slovic's research is further validated by his involvement as an advisor to various U.S. government agencies including the Food and Drug Administration, the Nuclear Regulatory Commission, NASA, the Environmental Protection Agency, and the Pentagon.

Each of us, whether an ordinary person or a president, must consider risks and make decisions, both as an individual and as a member of our communities and the world at large. The work of Paul Slovic has provided innovative, original, and crucial insight into the ways humans carry out this vital part of living—and how we might be able to do it more effectively and more humanely.

Previous Recipients of the Bower Award and Prize for Achievement in Science

1990/91	PAUL C. LAUTERBUR
1991/92	SOLOMON H. SNYDER
1992/93	DENIS PARSONS BURKITT
1993/94	ISABELLA L. KARLE
1994/95	CHEN NING YANG
1995/96	FREDERICK P. BROOKS
1997	RALPH L. BRINSTER
1998	SIR MARTIN REES
1999	RALPH J. CICERONE
2000	ALEXANDER RICH
2001	PAUL BARAN
2002	JOHN W. CAHN
2003	PAUL B. MACCREADY
2004	SEYMOUR BENZER
2005	HENRI B. KAGAN
2006	NARAIN G. HINGORANI
2007	STUART K. CARD
2008	TAKEO KANADE
2009	SANDRA M. FABER
2010	W. RICHARD PELTIER
2011	GEORGE M. CHURCH
2012	LOUIS E. BRUS
2013	KENICHI IGA
2014	EDMUND M. CLARKE
2015	JEAN-PIERRE KRUTH
2016	WILLIAM J. BORUCKI
2017	CLAUDE LORUIS
2018	PHILIPPE HORVATH
2019	FRANCES H. ARNOLD
2021	KUNIIHIKO FUKUSHIMA

Prior to 1997, awards were designated by the year of nomination. Subsequently, awards were identified by the year of presentation.

LAUREATE SPONSOR:

Sharon Thompson-Schill, Ph.D.

Christopher H. Browne

Distinguished Professor of Psychology
Director, Center for Cognitive Neuroscience
University of Pennsylvania

Member of Committee of Science and the Arts
since 2013

BOWER AWARD FOR BUSINESS LEADERSHIP



Stéphane Bancel

Chief Executive Officer
Moderna
Cambridge, Massachusetts



*Albert Bourla,
DVM, Ph.D.*

Chairman and Chief Executive Officer
Pfizer Inc.
New York, New York



Alex Gorsky

Executive Chairman
Johnson & Johnson
New Brunswick, New Jersey

CITATION: For their collective leadership during the COVID-19 crisis, principally the development and distribution of exceptionally effective vaccines on an unprecedented timescale.

When the SARS-CoV-2 coronavirus broke out in late 2019, it launched the deadliest pandemic in a century. Crucially, due to decades of creative and diligent research, the scientific foundation for the vaccines that would constitute the main weapon against the virus were already at hand. But even the most effective vaccines cannot quell a raging pandemic if they cannot be quickly manufactured in mass quantities and then widely distributed. Stéphane Bancel, Albert Bourla, and Alex Gorsky are three visionaries whose foresight, energy, and leadership made it possible for COVID-19 vaccines to reach the market on an unprecedented timescale, saving millions of lives.

Vaccines are undoubtedly one of the greatest achievements in science history. From polio to measles to meningitis, vaccines of many types have allowed countless people to evade serious illness and death. But the journey from initial conception to practical application has many stages to ensure safety and efficacy. The development of prior vaccines for infectious diseases has generally taken 8 to 12 years. In the confusing, desperate early days of the COVID-19 pandemic, the best estimates from authorities such as the World Health Organization predicted that at

least 18 months would be needed to develop an effective vaccine—an estimate that seemed ambitious at the time. Meanwhile, SARS-CoV-2 continued to spread relentlessly, and its death toll continued to climb.

For Albert Bourla, a former veterinarian, now Chairman and CEO of pharmaceutical giant Pfizer, it was clear that the situation required swift and unprecedented action. He immediately marshaled Pfizer's vast resources to develop a COVID-19 vaccine and possible treatments, accepting the possibility that it could cost billions of dollars that would not be recouped. The company partnered with German biotech firm BioNTech to focus on an mRNA vaccine platform, despite the fact that no one yet knew whether mRNA vaccines were up to the task, and without any assurance of eventual regulatory approval. Meanwhile, he took steps to ensure that the production of other Pfizer drugs that might be in high demand would not be disrupted and result in dangerous shortages. Bourla also encouraged his scientists to share their data early with the research community to help other companies with their own COVID-19 efforts and struck agreements to use extra Pfizer manufacturing capacity to make vaccines developed by competitors.

Moderna CEO Stéphane Bancel did not have the immense resources of Pfizer immediately on hand when COVID hit, but he had realized the pandemic's imminent threat in late 2019, even while the virus was still thought to be contained in China. He recognized that his company, which was launched to explore and develop mRNA technology, was perfectly positioned to hit the ground running. Moderna, co-founded by 2016 Benjamin Franklin Medalist Robert Langer, had already conducted clinical trials for nine other mRNA vaccines for influenza and other infectious diseases. Bancel and his management team knew that their first task was to scale their 800-employee startup to meet the development and manufacturing challenge. Quickly, Moderna more than doubled its workforce and forged strategic global partnerships to get the job done. With no guarantee of success and great financial investment, the bioengineer and former pharmaceutical salesperson Bancel accepted this risk for his just 10-year-old company to accelerate the fight against the pandemic.

Like Pfizer, Alex Gorsky's company, Johnson & Johnson (J&J), was a huge and well-established player in the pharmaceutical landscape, and immediately recognized that SARS-CoV-2 posed a major global threat. J&J was able to quickly leverage the adenovector vaccine technology platform the company had been developing for over a decade to combat the transmission of infectious diseases including Ebola and HIV. As a former military officer, J&J Chairman and CEO Gorsky knew the power of uniting behind a shared mission—and the wisdom of taking multiple approaches to fighting a common enemy.

As it happened, both the mRNA vaccines of Pfizer/BioNTech and Moderna and the adenovirus vector strategy of J&J worked better than anyone had hoped. Clinical trials and subsequent studies proved their effectiveness in sharply reducing severe illness and death. Before the end of 2020, less than a year after the genetic sequence of the virus was published, vaccines were going into arms—thanks to the massive investment of resources in the public and private sectors, tens of thousands of volunteers for clinical trials, and accelerated regulatory review. The rapidly spreading virus quickly put the vaccines to the test. Even as the Delta and Omicron variants slowed progress in stopping the pandemic, the vaccines proved to be remarkably robust. Work continues to improve and enhance their efficacy with an eye toward achieving a single vaccine that will defend against any future SARS-CoV-2 variants.

Together, Stéphane Bancel, Albert Bourla, and Alex Gorsky led a risky and ambitious effort comparable to how industries pivoted to wartime production in the 1940s, marshaling the resources of their companies to battle an unexpected global health crisis. Their visionary leadership not only continues to save lives today but sets a new example for innovation and collaboration for the good of humanity in the future.

Previous Recipients of the Bower Award for Business Leadership

1990/91	JAMES EDWARD BURKE
1991/92	DAVID TODD KEARNS
1992/93	ARNOLD O. BECKMAN
1993/94	ROBERT W. GALVIN
1994/95	JOAN GANZ COONEY
1995/96	DAVID PACKARD
1997	GEORGE B. RATHMANN
1998	JOHN C. DIEBEL
1999	P. ROY VAGELOS
2000	WILLIAM J. RUTTER
2001	IRWIN MARK JACOBS
2002	GORDON E. MOORE
2003	HERBERT D. KELLEHER
2004	RAYMOND V. DAMADIAN
2005	ALEJANDRO ZAFFARONI
2006	R. E. (TED) TURNER
2007	NORMAN R. AUGUSTINE
2008	FREDERICK W. SMITH
2009	T. BOONE PICKENS
2010	WILLIAM H. GATES III
2011	FRED KAVLI
2012	JOHN T. CHAMBERS
2013	MICHAEL S. DELL
2014	WILLIAM W. GEORGE
2015	JON M. HUNTSMAN
2016	PATRICK SOON-SHIONG
2017	ALAN R. MULALLY
2018	ANNE M. MULCAHY
2019	INDRA K. NOOYI
2021	ARTHUR D. LEVINSON

Prior to 1997, awards were designated by the year of nomination. Subsequently, awards were identified by the year of presentation.

LAUREATE SPONSOR:

Michael Useem, Ph.D.

*Chair, Bower Award for Business Leadership
Selection Committee*

*William and Jacalyn Egan Professor of
Management*

*Director, Center for Leadership and
Change Management*

*Wharton School of the
University of Pennsylvania*

BENJAMIN FRANKLIN NEXTGEN AWARD



Kafui Dzirasa, M.D., Ph.D.

K. Ranga Rama Krishnan Associate Professor
Collective for Psychiatric Neuroengineering
Chief Vision and Values Scientist
Duke University Medical Center
Durham, North Carolina

CITATION: For studies investigating how stress and other environmental factors affect the brain through genetic and electrochemical mechanisms, which led to important insights into cognitive and emotional function and depressive disorders.

We all know how it feels to be stressed out, but for most of us, it is usually a temporary state. Sometimes, however, ongoing and unrelenting stress can have more lasting effects, changing the actual microstructure of neural circuitry deep within the brain and contributing to serious conditions such as major depressive disorder (MDD). For decades, ever since it was identified as a specific psychological malady, various techniques have been used to treat major depression, including psychotherapy, electroshock, and pharmaceuticals. But all these interventions have proved limited, lacking an understanding of the brain mechanisms of a person with

MDD. Kafui Dzirasa is striving to understand these brain mechanisms, and to use them to develop better and more effective treatments.

Dzirasa's approach focuses on understanding MDD at its roots: at the molecular and neurobiological level, in the intricate circuitry and vastly complex interconnections of the brain. Many factors shape the form that brain circuitry takes, including genetics and life experiences, and the particulars of those factors shape an individual's susceptibility to MDD and how they might respond to different treatments. Trained not only as a neurobiologist but also as an engineer and physician, with experience both in the laboratory and in the clinic with real patients, Dzirasa is uniquely equipped to consider questions from a multidisciplinary perspective.

The son of Ghanaian immigrants, Dzirasa grew up near Baltimore, Maryland, and at first planned on becoming a chemist, studying at the University of Maryland, Baltimore County as part of the Meyerhoff Scholars Program. He switched gears as an undergraduate and earned a B.S. in chemical engineering, then moved on to graduate work at Duke University, planning to focus on biomechanics and biomedical engineering. A medical school rotation in the state psychiatric hospital changed his mind, and made him realize that he wanted to help those suffering from mental illness more directly than was possible solely in the laboratory. He earned his M.D. in 2009 at Duke University School of Medicine, while also becoming the first African-American student to earn a Ph.D. in neurobiology at Duke in 2007.

His early work centered on mouse models, with his first notable publications describing experiments on the workings of the sleep-wake cycle. By recording electrical activity in multiple brain regions of live mice, he showed that low dopamine levels interfere with REM sleep and that dopamine-mimicking compounds can effectively treat this condition. In this and subsequent research, he took advantage of his engineering background to develop computational algorithms and data analysis techniques to evaluate data and to better integrate it with genetic and pharmacological findings.

Dzirasa had observed, firsthand, the toll of depression and mental illness in his own family, which motivated him to begin his investigations of the neuronal circuitry of depression while doing his residency in psychiatry

at Duke University Hospital. He also continued working with mouse models, using genetically engineered mice to explore a new model of depression based on susceptibility to environmental stress. He further developed and refined machine learning methods to analyze large datasets from neurophysiological and neurological research and to examine the possible relationships and causalities among different brain mechanisms and genetic models. Now an associate professor at Duke and an Investigator in the Howard Hughes Medical Institute, he continues his groundbreaking interdisciplinary research.

Dzirasa's passion for creative scientific research is matched only by his dedication to public science communication and education.

Dzirasa's passion for creative scientific research is matched only by his dedication to public science communication and education. One of his most important endeavors is advancing diversity and inclusivity for historically excluded groups both in neuroscience and in mental health programs and treatment approaches, including the recognition of genetic diversity in neuroscience. His own experiences throughout his career have made him an outstanding mentor to and advocate for underprivileged students and scientists in science and academia.

Kafui Dzirasa's accomplishments to date promise an exciting future as a scientist and scholar. As a physician, neuroscientist, engineer, and educator, he is a Renaissance man for the 21st century, bringing together different scientific disciplines to forge new directions in all of them. His work is not only providing fresh answers to old questions about the psychological afflictions that have always troubled humankind, it is lighting the path to new ways to ease and heal the suffering caused by those afflictions.

Kafui Dzirasa's Laureate Legacy

The laureate legacy recognizes previous laureates connected to the current laureate by a shared intellectual thread.

1998	STANLEY B. PRUSINER
2003	JANE GOODALL
2004	SEYMOUR BENZER
2006	FERNANDO NOTTEBOHM
2007	NANCY SABIN WEXLER
2011	GEORGE M. CHURCH
2013	RUDOLF JAENISCH
2015	CORNELIA BARGMANN
2017	MICHAEL I. POSNER

Please note that the laureate legacy does not represent a comprehensive list of all Franklin Institute medalists.

Learn more about Dr. Dzirasa and his work at “Inspiring Minds” on April 19 and at “Social Innovation: From Bench to Society” on May 5.

— See page 4 for details.

LAUREATE SPONSOR:

Maja Bucan, Ph.D.

*Vice Chair, Committee on Science and the Arts
Life Science Cluster*

Professor of Genetics

Perelman School of Medicine,
University of Pennsylvania

Member of Committee of Science and the Arts
since 2006

BENJAMIN FRANKLIN MEDAL IN BIOMEDICAL ENGINEERING



Sheldon Weinbaum, Ph.D.

CUNY Distinguished Professor of Biomedical and
Mechanical Engineering, Emeritus
The City College of New York
New York, New York

CITATION: For foundational contributions to our understanding of heat flow among arteries, veins, and capillaries in the body, increasing our knowledge of cardiovascular disease and leading to life-saving technologies.

in the 1960s and 1970s, Weinbaum found himself swept up into the societal struggles against prejudice and injustice, once protesting his employer's discriminatory hiring practices and being fired as a result. He joined the faculty at City College of New York (CCNY) in 1967 and changed his focus to biomechanics, an interest he had developed during his earlier corporate career. At CCNY, he would now work to teach new generations of engineers and to improve human health, simultaneously pursuing his passions for engineering and for social justice.

As an engineer, Weinbaum is globally recognized as a leader in biomechanics. While many biomechanical engineers tend to specialize in one or two specific human anatomical systems, Weinbaum's contributions range across the numerous mechanical functions of the body, with creative new insights into cardiovascular disease, heat exchange between blood and the surrounding tissue, cholesterol (LDL) transport, bone fluid flow, capillary fluid exchange, and eye disease. His very first work in biomechanics, done in his spare time when he was still employed as an aerodynamicist, provided a seminal model for intraocular fluid pressure and its relation to the blinding disease of glaucoma. His aerodynamics work also informed his later studies in blood flow and lubrication theory. He found that the fluid dynamics of red cells skiing on the endothelial lining of your capillaries have a remarkable similarity to humans skiing on snow. He also demonstrated that it is possible to design a high-speed train whose weight was supported by a giant ski gliding on inexpensive fiber fill materials if the leakage of air at the edges of the ski could be eliminated.

With a combination of great scientific knowledge, intuitive insight, and creative imagination, Weinbaum's approach is to solve outstanding mysteries whose solutions have eluded other researchers. One example involves atherosclerosis, the silent but deadly buildup of plaque inside our arteries that underlies heart disease. Weinbaum showed how previously unknown mechanisms in the cells lining our arteries promote the development and growth of plaques that can lead to heart attack and stroke. His team also discovered how tiny particles of calcium in the thin fibrous caps of vulnerable lesions aggregate, which can lead to cap rupture and sudden death.

Focusing elsewhere in the body, he discovered and modeled the mechanisms by which bone cells can detect

The human body is a finely tuned and enormously sophisticated system and understanding the physics and mechanics of how it functions is essential to health. This is the realm of biomechanics, in which Sheldon Weinbaum has blazed new trails for decades as a biomedical engineer.

Growing up as a math prodigy who was interested in science from a young age, Weinbaum did not start out intending to work on subjects like blood flow, bioheat transfer, or transport aspects of arterial disease. After earning his undergraduate BAE degree from Rensselaer Polytechnic Institute in 1959 and his doctorate in engineering from Harvard in 1963, when both the Cold War and the Space Age were at their height, he worked for space and defense contractors on problems of high altitude aerodynamics. But

mechanical strains and induce bone-forming cells to adapt; contributed to the understanding of the flow and filtration of fluids through tissues and capillaries; provided vital work on the mechanical signals regulating kidney function; and developed a new theory of heat exchange between tissues and blood vessels with the Weinbaum-Jiji equation (one of several important equations that bear his name). Throughout his career, Weinbaum's insights and models have changed or improved the conventional wisdom in many areas of biomechanical research, resulting in life-saving new treatments and procedures. His is truly a lifetime of innovation and reduction to successful practice.

... Weinbaum's approach is to solve outstanding mysteries whose solutions have eluded other researchers.

Beyond his scientific contributions, Weinbaum's career is also a story of advocacy on behalf of minorities and women in science and engineering—opportunities that have been a key factor in his decision to spend his entire academic career at CCNY. He set up the first CCNY summer outreach program for city high schools and worked tirelessly to recruit outstanding minority and women faculty members for the School of Engineering. He led initiatives to increase minority participation not only at CCNY but also across scientific disciplines, through efforts including the identification of diverse candidates for election to the National Academies of Science, Engineering, and Medicine (Weinbaum is one of few who are members of all three). He also led a class-action lawsuit against the State of New York for racially discriminatory practices in higher education funding.

For Sheldon Weinbaum, devising new equations to explain blood flow or working to ensure that marginalized students have the chance to reach their full potential as scientists and engineers all grow from the same motivating passion: to serve humanity while using science and technology to enhance and prolong life.

Sheldon Weinbaum's Laureate Legacy

The laureate legacy recognizes previous laureates connected to the current laureate by a shared intellectual thread.

1913	EMIL FISCHER
1918	GUGLIELMO MARCONI
1933	ORVILLE WRIGHT
1970	JACQUES-YVES COUSTEAU
1972	OTTO HERBERT SCHMITT
1972	GEORGE B. KISTIAKOWSKY
2001	JUDAH FOLKMAN
2004	SEYMOUR BENZER
2005	ELIZABETH HELEN BLACKBURN
2016	ROBERT S. LANGER

Please note that the laureate legacy does not represent a comprehensive list of all Franklin Institute medalists.

Learn more about Dr. Weinbaum and his work at "From Solving Mysteries in Cellular Biomechanics, to Vulnerable Plaque Rupture, to Jet Trains that Ski" on May 4.

— *See page 4 for details.*

LAUREATE SPONSORS:

Gerard F. Jones, Ph.D.
Professor, Department of
Mechanical Engineering
Senior Associate Dean for Graduate Studies and
Research, College of Engineering
Villanova University
Member of Committee on
Science and the Arts since 2005

Bradford A. Jameson, Ph.D.
Chair, Committee on Science and
the Arts Life Science Cluster
Professor, Department of Biochemistry and
Molecular Biology
Drexel University College of Medicine
Member of Committee on Science and the Arts
since 1998

BENJAMIN FRANKLIN MEDAL IN CHEMISTRY



*Carol V. Robinson DBE, FRS,
FRSC, FMedSci*

Director of the Kavli Institute for
Nanoscience Discovery
Dr Lee's Professor of Physical Chemistry
University of Oxford
Oxford, United Kingdom

CITATION: For developing techniques for analyzing interactions of biological molecules such as proteins and lipids, thus elucidating their biological functions and assisting in pharmaceutical discovery.

For more than a century, mass spectrometry has been an important analytical technique that separates and measures the molecular components in a chemical sample. Carol Robinson is one of the early visionary scientists who realized that this same technique could be adapted to study a range of biomolecules to yield invaluable information on their structure, function, and interactions. Her subsequent career has been devoted to developing and refining mass spectrometry methods to investigate proteins and their complexes. Today, Carol Robinson's name is synonymous with research into mass spectrometry of proteins and their complexes and her

work has wide-reaching application in fields from protein structure and function to drug design and discovery.

Robinson's path to becoming a world-class scientist began somewhat unconventionally. Growing up in England and fascinated at an early age by all sorts of living creatures from wildflowers to stick insects, she did not proceed directly to university, instead leaving school at age 16 to take a laboratory technician position at the pharmaceutical giant Pfizer. There, she discovered a passion and a distinct talent for hands-on laboratory work, especially mass spectrometry, the technique that would eventually dominate her career. Her supervisor noticed her scientific ability and encouraged her to return to studying. Still working at Pfizer and honing her laboratory skills, she studied chemistry part-time, then moved on to graduate school, ultimately earning her doctorate at the University of Cambridge. After stepping back from academia for eight years to raise her three children, she resumed her scientific career as a postdoctoral researcher, and subsequently as a Royal Society research fellow, at the University of Oxford.

Robinson's research has led to the refinement and expansion of native mass spectrometry as an indispensable part of the toolkit of structural biology.

Robinson's early work centered on using mass spectrometry to investigate protein folding. Her initial experiments, however, attracted some controversy: it was widely thought that proteins would invert in the absence of water and she therefore had to work out how to maintain proteins intact in their folded state, during the transition from solution to vacuum in the mass spectrometer. She worked on developing mass spectrometers designed to preserve and analyze macromolecular complexes, a challenging task since the weak interactions among such biomolecules are readily disrupted by the process of moving them out of their natural cellular environment into a gas phase. Later, using ion mobility mass spectrometry she showed that the overall topology of protein complexes could be preserved, overcoming reservations that existed in the field and adding a new dimension to the study of protein complexes.

At that time, Robinson's research led to the refinement and expansion of native mass spectrometry, which today has become an indispensable part of the toolkit of structural biology.

Most recently, Robinson has extended the capabilities of native mass spectrometry to study proteins and protein complexes that are normally embedded in the cell membrane, an additional challenge since physical interactions with the membrane significantly influence their structure and function. First in solutions of detergent, she and her collaborators developed a means of extracting membrane protein complexes directly from the cell membrane, protecting them effectively in giant soap bubbles before effecting their release into the mass spectrometer, another achievement previously thought impossible. Since about 70% of targets for drug therapies involve membrane-embedded proteins, this accomplishment promises enormous potential for pharmaceutical innovation. Robinson's spin-off company, OMass Technologies Ltd (now OMass Therapeutics), was formed in 2016 to help bring these techniques into broader use by pharmaceutical and biotechnology companies.

While Robinson was pushing the boundaries of native mass spectrometry, she was likewise challenging societal assumptions and limitations in a far larger arena. In 2001, she became the first female professor of chemistry at the University of Cambridge, and eight years later, the first female professor of chemistry at the University of Oxford, thus breaking the glass ceiling at two institutional pillars of the scientific establishment. She has also supervised and mentored more than 100 post-graduate students, postdoctoral researchers, and early career fellows, among them many scientists with young families and female scientists, thus serving as a stellar role model for all young scientists embarking on their careers. In 2013, in recognition of her exceptional achievements, Robinson was appointed Dame Commander of the Order of the British Empire.

Carol Robinson's success as a woman in a traditionally male-dominated field is a testament to her determination, her unorthodox and daring approaches to seemingly unsolvable problems, and her ability to think beyond conventional, long-accepted ideas. Her scientific and technical innovations have transformed a long-established instrument of scientific research into an even more important and versatile tool in ways that will open up new horizons of discovery for decades to come.

Dame Carol Robinson's Laureate Legacy

The laureate legacy recognizes previous laureates connected to the current laureates by a shared intellectual thread.

1910	ERNST RUTHERFORD
1910	J. J. THOMSON
1916	THEODORE WILLIAM RICHARDS
1917	HENDRIK ANTOON LORENTZ
1924	ERNST RUTHERFORD
1937	R. A. MILLIKAN
1959	RICHARD LAURENCE MILLINGTON SYNGE, ARCHER JOHN PORTER MARTIN, AND A. T. JAMES
1985	WILLIAM COCHRAN
1996	WILLIAM D. PHILLIPS
2007	KLAUS BIEMANN
2014	JOACHIM FRANK

Please note that the laureate legacy does not represent a comprehensive list of all Franklin Institute medalists.

Learn more about Professor Dame Carol Robinson and her work at "Exploring Intact Protein Assemblies with Mass Spectrometry" on May 2.

— *See page 4 for details.*

LAUREATE SPONSOR:

Sharon Rozovsky, Ph.D.
Associate Professor, Department of
Chemistry and Biochemistry
University of Delaware
Member of Committee of Science and the Arts
since 2018

BENJAMIN FRANKLIN MEDAL IN EARTH AND ENVIRONMENTAL SCIENCE



Sallie W. Chisholm, Ph.D.

Institute Professor
Massachusetts Institute of Technology
Cambridge, Massachusetts

CITATION: For her leading role in the discovery of *Prochlorococcus*, a marine microorganism that is the most abundant photosynthetic organism known, and for her pioneering studies exploring the role of *Prochlorococcus* and other ocean microbes in global chemical cycles and Earth's climate.

Some of the most important lifeforms on Earth are never seen or encountered by most humans, yet without them, practically all life on Earth would be impossible. These lifeforms are phytoplankton, microscopic organisms living in all of Earth's lakes, streams, and oceans, producing half of all atmospheric oxygen through photosynthesis. Understanding phytoplankton is not just a matter of scientific interest but key to the continued survival of life, even as these precious organisms are impacted by human activities. One of the most important single members of the vast array of phytoplankton varieties is a cyanobacterial genus called *Prochlorococcus*. Sallie "Penny" Chisholm played a leading role in the discovery of

Prochlorococcus and has dedicated her career to studying it and the role of marine microorganisms in maintaining the ocean ecosystem.

Not only do phytoplankton carry out about half of all the photosynthesis on Earth, they feed all life in the sea. It is only in about the last century that we have come to appreciate the role they play in the global cycling of carbon dioxide. Up until the mid-1970s, it was thought that the smallest phytoplankton were about 1/10th the width of a human hair. But there were hints that scientists were missing something—that there could be much smaller cells out there, and that they might be very abundant. Those phytoplankton were just too small to see, even with the most powerful microscopes of the time. In 1979, the introduction of fluorescent microscopy to oceanography revealed some ubiquitous, small, and abundant cyanobacteria in the sea—*Synechococcus*—which expanded the size distribution of phytoplankton in seawater. But that was just the beginning of a new chapter.

In 1987, Chisholm and her colleagues acquired an instrument used in medical research to study cancer cells—a flow cytometer, which allows one to measure properties of individual cells as they pass one-by-one through a laser beam. The research team put it on a ship, and set off to the Sargasso Sea. When they pumped seawater through it, they observed very tiny cells with properties that showed that they contained chlorophyll, the pigment plants use in photosynthesis. After comparing their data with observations by other researchers and collecting samples in other areas, they identified *Prochlorococcus* for the first time, publishing their results in *Nature* in 1988. Further research showed that *Prochlorococcus* is smaller and even more abundant than *Synechococcus*, making it the smallest and most abundant photosynthetic cell on the planet. Later, Chisholm's genomic studies showed it to be one of the most genetically diverse types of phytoplankton, allowing it to survive and thrive in a broad range of marine environments, one factor contributing to its prevalence and centrality in the oceanic carbon cycle and the global ecosystem. Through studying *Prochlorococcus* from its genome to the global oceans, Chisholm showed that to understand what shapes our living planet, we need to study life at all scales. In doing so, we learn that each species has a lot to teach us about how living systems have evolved and shape our world today.

Born and raised in the Upper Peninsula of Michigan, Chisholm spent her childhood exploring the outdoors on Lake Superior. She earned her undergraduate degree from Skidmore College in 1969 and her doctorate from SUNY Albany in 1974. After a post-doctoral fellowship at Scripps Institution of Oceanography, she has spent her entire career at MIT, while also working as a visiting researcher at the nearby Woods Hole Oceanographic Institution. Yet Chisholm's influence ranges far beyond her own field and the generations of students she has trained, many of whom have gone on to their own distinguished careers in oceanography, biology, and related disciplines.

Through studying Prochlorococcus from its genome to the global oceans, Chisholm showed that to understand what shapes our living planet, we need to study life at all scales.

As the effects of climate change become increasingly clear and damaging, the significance of preserving and protecting our oceans and the varieties of life they harbor has assumed ever-greater public visibility as well as inclusion in debates on political and social policy. Chisholm is a prominent voice in the public forum on climate change issues, in particular the risks of proposed ocean geoengineering, serving as a tireless spokesperson for and defender of the Earth's oceans. Throughout her career, she has also been dedicated to public education and outreach, helping people to understand and share her deep respect for the seas and oceans of our planet and the critical need to uncover their mysteries and to protect them. These efforts extend to even the youngest stewards of our planet. Chisholm has authored a series of children's books—the "Sunlight Series"—which explain how the Sun and photosynthesis support life on Earth, the importance of our oceans, and the history of fossil fuel and how it impacts Earth's climate.

Through her research, her teaching and mentorship, and her example as a scholar and scientist, Penny Chisholm has spent an entire career dedicated to advancing and expanding the boundaries of her own field, playing an indispensable role in creating a more profound understanding and appreciation for the intricately woven web of life on Earth.

Sallie Chisholm's Laureate Legacy

The laureate legacy recognizes previous laureates connected to the current laureate by a shared intellectual thread.

1925	HARVEY C. HAYES
1973	THEODOSIUS GRIGOREVICH DOBZHANSKY
1979	G. EVELYN HUTCHINSON
1987	WILLIAM A. NIERENBERG
1989	PETER H. RAVEN
1999	RALPH J. CICERONE
2000	EVILLE GORHAM
2008	VICTOR AMBROS, DAVID BAULCOMBE, AND GARY RUVKUN
2008	WALLACE BROECKER
2009	J. FREDERICK GRASSLE
2010	W. RICHARD PELTIER
2011	JILLIAN F. BANFIELD
2011	GEORGE M. CHURCH
2012	SEAN B. CARROLL
2013	ROBERT A. BERNER
2015	SYUKURO MANABE
2017	CLAUDE LORIS
2018	SUSAN TRUMBORE
2019	GENE E. LIKENS

Please note that the laureate legacy does not represent a comprehensive list of all Franklin Institute medalists.

LAUREATE SPONSOR:

Helen K. White, Ph.D.
Associate Professor of Chemistry
Haverford College
Member of Committee of Science and the Arts
since 2014

BENJAMIN FRANKLIN MEDAL IN ELECTRICAL ENGINEERING



P. Daniel Dapkus, Ph.D.

Professor Emeritus of Electrical and
Computer Engineering
University of Southern California
Los Angeles, California

CITATION: For pioneering the technology that provides the materials quality and ultra-precision required for many device components central to modern life, including LEDs, transistors, lasers, and high-performance solar cells.



Russell D. Dupuis, Ph.D.

Steve W. Chaddick Endowed Chair in Electro-Optics
and Georgia Research Alliance Eminent Scholar
Director, Center for Compound Semiconductors
Professor, School of Electrical and
Computer Engineering
Professor, School of Materials Science and Engineering
Georgia Institute of Technology
Atlanta, Georgia

Almost all the wonderful gadgets we use every day to work, play, and communicate are made possible by various types of semiconductor materials, created through several different techniques depending on the particular electronic characteristics required. One of the most important techniques is called metalorganic chemical vapor deposition (MOCVD). P. Daniel Dapkus and Russell Dupuis advanced MOCVD from an interesting laboratory technique to its full potential as a major commercial production technology for the semiconductor industry.

Invented at the Rockwell International company by Harold Manasevit, MOCVD was ripe for further investigation and development when Russell Dupuis joined the company in 1975. Compound semiconductors, which combine different materials into a single alloy, were coming into

their own, and Dupuis was one of several researchers at Rockwell and elsewhere who began exploring how MOCVD could be used to manufacture high-quality semiconductors. When Daniel Dapkus joined Rockwell soon after Dupuis, the two refined MOCVD, showing that it was better-suited, yet more economical, than other techniques for creation of complex semiconductor structures. This resulted in mass-producible, efficient, and practical optoelectronic devices, such as solar cells, LEDs, and laser diodes, and included quantum well lasers—the device that is now at the heart of all fiber optic communications.

Dupuis and Dapkus followed similar paths that almost inevitably seemed to bring them together. Both native sons of Illinois and alumni of the University of Illinois at Urbana-Champaign, each had a fascination with science encouraged by the post-Sputnik boom in American

science education and the birth of the U.S. space program. Ultimately, they would become the vanguard of a new generation of semiconductor pioneers. From Nobel Laureate John Bardeen, the co-inventor of the transistor, to Nick Holonyak, Bardeen's student and the inventor of the visible-light LED—both recipients of Franklin Institute Awards—to Dupuis and Dapkus, who studied as graduate students under Holonyak, each would build upon and further develop their predecessor's work into ever-expanding realms of importance.

Before Dapkus and Dupuis transformed MOCVD into a practical, scalable method for the manufacture of III-V semiconductor crystalline structures a type well-suited for optoelectronics, devices such as LEDs and lasers were expensive to produce by existing methods and rather inefficient in their operation. With the maturation of MOCVD, however, the great potential of optoelectronics finally came to fruition. The proof is all around us not only in the LED arrays in our flatscreen televisions and computer monitors, but in the ever-increasing ways in which LEDs and other optoelectronic components are employed in lighting, generate energy for heating homes, and produce the devices that carry and decode information on the internet.

Apart from their versatility and long life, such devices offer another crucial advantage: energy efficiency. LEDs are about four times as efficient as fluorescent lighting and 20 times as efficient as incandescent lighting, advantages that directly translate into a savings of billions of dollars in energy costs and substantial reduction in carbon emissions. For sustainable energy generation, MOCVD has enhanced the design and manufacture of semiconductor photovoltaic devices for solar energy both on Earth and in solar-powered spacecraft, including Martian rovers, the International Space Station, and hundreds of commercial, scientific, and military satellites.

The MOCVD technique perfected by Dupuis and Dapkus can also be said to have made the modern high-speed internet possible, by making the quantum well laser an efficient, economical, and practical foundation of fiber optic communications. Of course, the internet existed before fiber optics became a viable commercial technology, but it was bound by the speed and bandwidth limitations of copper wires and electrical signals. The advent of laser diodes such as the quantum well laser allowed engineers to free computer networks from those constraints, leading to the enormous speeds that have given us streaming video services and Zoom conferencing. Indeed, perhaps the most significant and lasting tribute that can be paid to Daniel Dapkus and Russell Dupuis is the acknowledgement that we use and depend upon their work and creativity practically every day.

P. Daniel Dapkus and Russell Dupuis's Laureate Legacy

The laureate legacy recognizes previous laureates connected to the current laureate by a shared intellectual thread.

1952	JOHN BARDEEN AND WALTER H. BRATTAIN
1971	ZHOES I. ALFEROV
1995	ALFRED Y. CHO
1997	FEDERICO CAPASSO
2002	SHUJI NAKAMURA
2017	NICK HOLONYAK, JR

Please note that the laureate legacy does not represent a comprehensive list of all Franklin Institute medalists.

Learn more about Dr. Dapkus and Dr. Dupuis and their work at "Layer by Atomic Layer: MOCVD Growth for a Carbon Neutral Society" on May 4.

— *See page 4 for details.*

18

LAUREATE SPONSOR:

Babram Nabet, Ph.D.

Professor, Electrical and Computer
Engineering Department
Drexel University

Member of Committee of Science and the Arts
since 2015

BENJAMIN FRANKLIN MEDAL IN LIFE SCIENCE



Katalin Karikó, Ph.D.

Adjunct Professor of Neurosurgery
Perelman School of Medicine,
University of Pennsylvania
Philadelphia, Pennsylvania

Senior Vice President
BioNTech SE
Mainz, Germany



Drew Weissman, M.D., Ph.D.

Roberts Family Professor of Vaccine Research
Perelman School of Medicine,
University of Pennsylvania
Philadelphia, Pennsylvania

CITATION: For fundamental research enabling the use of mRNA as a safe, effective, and life-saving vaccine platform for the prevention of infectious disease, including COVID-19.

In the early months of 2020, as the singular threat of SARS-CoV-2 was establishing itself as the worst pandemic in a century, the immediate prospects seemed bleak. Although the genome of the virus was sequenced quickly, its virulence and rapid spread led many to despair that it could not be controlled and stopped before COVID-19 claimed an enormous toll of lives. It was clear that, as with communicable diseases of the past, a safe and effective vaccine would be the ultimate weapon against the virus, but how to find a vaccine for a brand new version of a pathogen only seen in different forms previously? Fortunately, scientists did not have to start from scratch. Katalin Karikó and Drew Weissman had been among a cadre of inventive and creative researchers who had already spent years laying the groundwork for an entirely new approach to vaccines—one based on messenger RNA (mRNA).

The potential of mRNA for vaccines or disease therapies was considered little more than an interesting but highly unlikely prospect for many years. A vital component of the cellular protein production pathway, mRNA was simply thought to be too unstable to be used outside the cell. It was also shown to trigger a severe and sometimes fatal inflammatory response in test animals, with the body's own immune system attacking mRNA as if it were a foreign intruder. There appeared to be no practical way to overcome these obstacles, and RNA therapy seemed a scientific dead end.

Karikó and Weissman thought differently. They were both fascinated by RNA, and in more than the basics: they wanted to explore how RNA in its various forms could fight disease. After a chance meeting while both faculty at the

University of Pennsylvania, they joined scientific forces to explore RNA vaccines and therapies. The challenges they faced were more than simply scientific. Because the idea of an mRNA-based vaccine was widely dismissed, funding for such research was hard to obtain. Still, they pressed on, convinced their research could blaze a new path in vaccine development. Finally, three biotech companies already keenly interested in the potential of mRNA—CureVac, Moderna, and BioNTech—agreed to support the research.

Weissman and Karikó devised a way to allow mRNA to evade the immune system response by altering one of its nucleotides. The modified version of mRNA could safely slip into a host cell and direct the synthesis of the encoded protein. To solve the stability problem, they found a way to package the mRNA molecule inside a lipid nanoparticle to protect and preserve it until it reached its final destination inside a cell. These fundamental breakthroughs, realized several years before anyone ever heard of COVID-19, formed the basis of the revolutionary vaccines manufactured by Pfizer/BioNTech and Moderna. When SARS-CoV-2 blindsided the world, the scientific tools were already in place to quickly create a remarkably effective vaccine that, slowly but surely, is enabling humanity to come to terms with this deadly disease.

Karikó and Weissman hail from very different backgrounds. Weissman was raised in comfortable middle-class surroundings in Massachusetts and schooled at Brandeis University and Boston University, later working with Dr. Anthony Fauci through a fellowship at the National Institutes of Health. Meanwhile Karikó spent the early part of her life in politically-repressive and economically-deprived Hungary, then still part of the Soviet Bloc. She earned her Ph.D. in biochemistry at the University of Szeged and then chose to pursue science in the U.S., emigrating in 1985.

Karikó and Weissman’s tenacious and determined work has also opened up a new range of exciting possibilities to battle AIDS, cancer, and cardiovascular disease through the application and further development of the mRNA technology that the COVID vaccines have vindicated so spectacularly. And as the SARS-CoV-2 virus continues to challenge science with new variants, they are in the forefront of efforts to develop a universal vaccine to protect against all existing COVID variants and any that might arise in the future. It is hardly an easy task, and one that some think is not possible or practical. But as Katalin Karikó, now a senior vice president of BioNTech, and Drew Weissman, who remains a professor of medicine at the University of Pennsylvania’s Perelman School of Medicine, can attest, the same thing was once said about mRNA vaccines—before they showed how it could be done.

Katalin Karikó and Drew Weissman’s Laureate Legacy

The laureate legacy recognizes previous laureates connected to the current laureate by a shared intellectual thread.

1915	THOMAS ALVA EDISON
1918	GUGLIELMO MARCONI
1933	ORVILLE WRIGHT
1970	JACQUES-YVES COUSTEAU
1987	STANLEY COHEN
2001	JUDAH FOLKMAN
2013	RUDOLF JAENISCH
2016	ROBERT S. LANGER
2018	PHILIPPE HORVATH

Please note that the laureate legacy does not represent a comprehensive list of all Franklin Institute medalists.

Learn more about Dr. Karikó and Dr. Weissman and their work at “Against the Odds” on May 2 and “The Future of mRNA Therapeutics” on May 4.

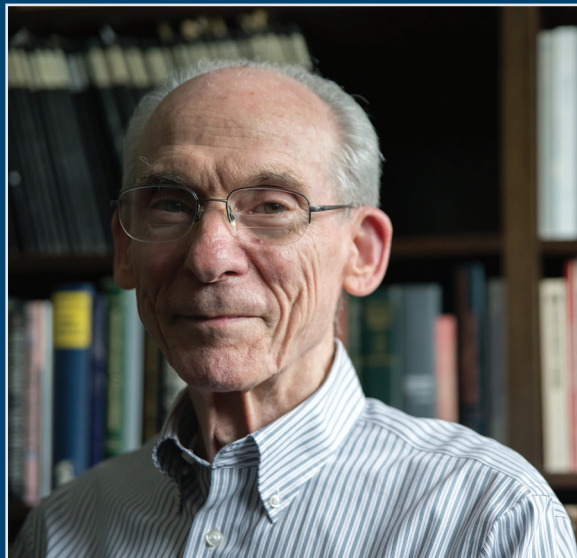
— See page 4 for details.

LAUREATE SPONSORS:

Bradford A. Jameson, Ph.D.
Chair, Committee on Science and the Arts Life Science Cluster
Professor, Department of Biochemistry and Molecular Biology
Drexel University College of Medicine
Member of Committee on Science and the Arts since 1998

Allen W. Nicholson, Ph.D.
Immediate Past Chair, Committee on Science and the Arts
Associate Dean for Faculty Affairs, College of Science and Technology
Professor, Department of Biology
Temple University
Member of Committee on Science and the Arts since 2007

BENJAMIN FRANKLIN MEDAL IN PHYSICS



Edward C. Stone, Ph.D.

Morrisroe Professor of Physics
Vice Provost for Special Projects
California Institute of Technology
Pasadena, California

CITATION:

For leading NASA's Voyager program in its exploration of the environments of Jupiter, Saturn, Uranus, and Neptune and for his vision to continue the mission on a 40-year journey beyond our solar system to transmit back information from interstellar space.

To shepherd the project, Stone led 11 teams of scientists, each responsible for a separate instrument. While handling the administrative and scientific demands of the first-ever detailed explorations of Jupiter, Saturn, Uranus, and Neptune, he also conducted his own research for the Voyager cosmic ray instruments. Their sensitivity was high enough to identify carbon and argon nuclei entering the solar system from the interstellar medium.

Raised in Burlington, Iowa, Stone grew up tinkering with radios and electronic gadgets, an interest that would serve him well later as a physics student at the University of Chicago. When Sputnik shook the world in 1957, he was a graduate student just as the new field of space physics was blossoming. After earning his doctorate in 1964, he became a research fellow at Caltech and designed and built experiments to fly into space as part of America's first generation of satellites. He became a full professor in 1976.

Stone knew the spacecraft had more to give and more to discover, because they were heading where nothing had gone before: the true beginnings of interstellar space.

Voyager was often overshadowed by the accomplishments of crewed spaceflight, but uncrewed planetary exploration was entering its first golden age, dispatching probes to Mars and Venus. The more distant worlds of the solar system soon came into reach. In the early 1970s, Pioneer 10 and 11 ventured beyond Mars to Jupiter and Saturn. It would be up to the Voyager missions to fulfill the discoveries at which Pioneer had only hinted.

NASA named Stone the Voyager project scientist in 1972. He found himself responsible for a complex scientific and exploratory endeavor. The Voyager probes launched in summer 1977, each reaching Jupiter in 1979. As the findings poured in, Stone became the public face of the project, patiently explaining the science and the workings of the spacecraft to the world at press conferences and media interviews. The spotlight returned in following years as the spacecraft flew by Saturn, Uranus, and Neptune.

More than 14 billion miles from Earth, traveling towards the stars at about 11 miles per second, flies an ambassador of humanity, a delicate and spindly craft about the size of a subcompact car. Heading in a different direction at a slightly slower speed is its identical counterpart. These are the Voyager spacecraft, standard bearers of one of history's greatest adventures of exploration and discovery, one that is still underway after 50 years. Both carry a cosmic message, a disc containing music, words, and images from Earth to any intelligent lifeforms that may recover them. From the beginning of their saga in 1972, Edward Stone has led the Voyager mission.

When Voyager at last swung by Neptune, most assumed the historic mission had finally come to an end. Stone had other ideas. As NASA, congressional and public attention drifted to new missions and programs, Stone, now director of the Jet Propulsion Laboratory, became the driving advocate for keeping Voyager alive. Stone knew the spacecraft had more to give and more to discover, because they were heading where nothing had gone before: the true beginnings of interstellar space.

Stone's tireless efforts succeeded in winning a new assignment (and funding) for Voyager, the Voyager Interstellar Mission (VIM). Still very much under way, VIM is providing observations of the heliosheath, where the sun's influence ends and interstellar space begins. Both Voyager spacecraft remain in contact with their distant home and are expected to operate until sometime later this decade, by which time their remaining power will be too low and their distance from Earth too great to sustain communications.

In the future, spacecraft will venture even further than the Voyagers. They will owe an incalculable debt to the spindly and fragile Voyagers 1 and 2 for blazing the way.

Edward Stone's Laureate Legacy

The laureate legacy recognizes previous laureates connected to the current laureate by a shared intellectual thread.

1960	WFG SWANN
1961	JAMES VAN ALLEN
1971	HANNES ALFVEN
1974	BRUNO ROSSI
1980	RICCARDO GIACCONI
1999	JOHN MATHER
2007	STEVEN SQUYRES
2012	RASHID SUNYAEV

Please note that the laureate legacy does not represent a comprehensive list of all Franklin Institute medalists.

LAUREATE SPONSOR:

*Thomas K. Gaisser, Ph.D.**
Professor, Bartol Research Institute
Martin A. Pomerantz Chair, Department of
Physics and Astronomy
University of Delaware
Member of Committee of Science and the Arts
since 1992

**deceased*

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2014 Bower Award for Business Leadership
Harvard Business School

Rajiv L. Gupta

Delphi Automotive PLC
Avantor Inc.

Ellen J. Kullman

DuPont, Retired

F. William McNabb III

Vanguard, Retired

Donald E. Morel, Jr., Ph.D.

Chair, The Franklin Institute Board of Trustees
West Pharmaceutical Services, Inc., Retired

Anne M. Mulcahy

2018 Bower Award for Business Leadership
Xerox Corporation, Former

Indra K. Nooyi

2019 Bower Award for Business Leadership
PepsiCo, Former

William J. Rutter, Ph.D.

2000 Bower Award for Business Leadership
Synergenics, LLC

Darryl N. Williams, Ph.D.

The Franklin Institute

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Perelman School of Medicine,
University of Pennsylvania

Karl Deisseroth, M.D., Ph.D.

Stanford University

Christian Doeller, Ph.D.

Max Planck Institute for Human Cognitive and Brain Sciences

Annie Duke

Member, The Franklin Institute Board of Trustees
The Alliance for Decision Education

John Duncan, D.Phil.

University of Cambridge

Marcia Johnson, Ph.D.

2019 Benjamin Franklin Medal in Computer and Cognitive Science
Yale University

Philip Rubin, Ph.D.

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- The committee carefully selects candidates using a thorough case investigation process to recognize those scientists and engineers who lead their fields, expand knowledge, and serve humanity.
- Individuals must be nominated for an invention, discovery, technological development, or a body of such work reflecting uncommon insight, skill, or creativity on the part of the candidate.
- The work must have significant scientific value or proven utility. It must have provided significant direction for future research, solved an important

problem, or provided great benefit to the public.

- Candidates for the award must be living persons.
- The Committee considers individuals from all over the world.

Committee members who become case sponsors represent their nomination cases before the full committee for review and action. Following successful case presentations, including the review of letters of evaluation solicited from preeminent experts in the field of the case, nominations are forwarded to the Institute's Board of Trustees for final review and approval. During the following spring, medalists are brought together at The Franklin Institute for the annual Awards Ceremony and Dinner and Awards Week celebration of science.

The all-volunteer Committee on Science and the Arts is composed of scientists and engineers from academia and industry. Meeting regularly throughout the year, it has a reputation for diligence and integrity. The committee's work reflects the mission of The Franklin Institute and provides a valuable service to the public and to the scientific community.

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– *Poor Richard's Almanack*, 1739

